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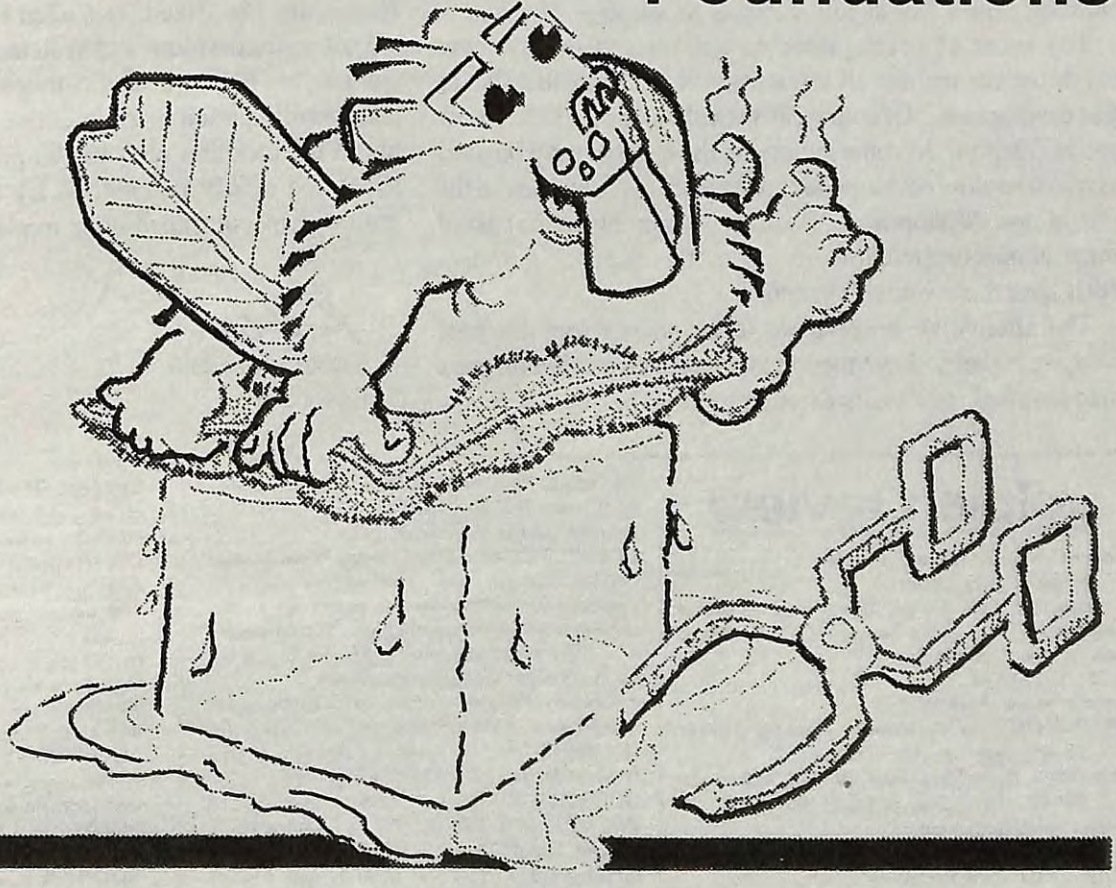
Contents . . .

Frost-Protected Shallow Foundations 3
Energy Use Patterns in Off-Grid Houses 6
Concrete House Awards Program 8
Energy Savings Tips 8
Higher Energy Prices Forecast 9
R-2000 Home Reduces Natural Gas Consumption by 70% 9
Can Building Codes Guarantee Building Performance? 10
Rooftop Gardens 10
Letters to the Editor 11
Technical Research Committee News 12
Proposed Changes to the National Building Code; Ontario Fall Protection Training Reminder!
The Value of Trees: Urban Trees Can Save Hundreds of Millions 13
Specifying Acoustical Criteria for Buildings 14
Energy Answers 16
Bubble Pack Foil Coated Insulation 18

Frost-Protected Shallow Foundations



From the Editor . . .

Be careful what you ask for because you may get it, only to regret it later.

Recently we've seen comments about the extremely high development cost charges on new properties in California. In some places they exceed $US 65,000 for a single-family property.

What is not recognized is that California's high development cost charges are the direct result of Proposition 13. That 1978 proposition, the result of a taxpayer revolt, put a straightjacket on governments, capped property tax rates, rolled back assessments, limited tax increases to levels below inflation, and set extremely stringent requirements before increases in local taxes could be implemented - and then only after increases were approved by referendum.

The result has been diminished revenues leading to cuts in public services, a deterioration of the public infrastructure, increases in other taxes, and a decrease in the state's credit rating. One of the most noticeable results is the high user-fees that communities charge to raise needed revenues for municipal expenditures. So the $60,000-plus DCCs and exorbitant building permit fees should come as no surprise.

The intent of development cost charges is to have new developments pay for all infrastructure costs attributable to that development. Of course, as with all things political, other issues creep in. In some situations the charges may be used as a tool to slow development, or at least place hurdles in the way of new development. Creative accounting on the part of some administrations diverts collected funds for purposes other than those initially intended.

The alternative is for there to be no development cost charges, rather to have the infrastructure costs paid off over time by property owners through local taxes.

Both approaches have their positive and negative sides.

Some say it is appropriate for new developments to pay their own way, and question why other taxpayers should pay for the cost of new development. Hence, the development cost charges, which can be hefty in some communities. However, high up-front charges do limit access to housing, and may be one way some communities aspire to control not only the nature of development, but also the demographics of the community.

Lower front-end costs but higher taxes may alter the population mix and enable more people to have a stake in their community, but at the cost of higher tax rates to pay what otherwise would be handled by DCCs. Then again, governments get a much better borrowing rate than individuals, who have to pay a higher retail mortgage rate to pay off the DCCs. So that having the community pay off the services should be cheaper in the long run.

Given the ideological zealousness of various Canadian provincial governments, the latest in BC, aiming to "fix the system," it is appropriate to be concerned just how that system might be "fixed" and what sort of constraints, if any, are put on the development system. Inevitably, there are no quick fixes. Before action is taken, there should be a frank and open discussion of the intentions and a clear understanding of the pros and cons of the proposed changes. These should be clearly understood by all concerned parties to ensure a smooth transition is made.

Richard Kadulski,
Editor

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Frost-Protected Shallow Foundations

Using slab-on-grade construction is not common in many parts of Canada because frost penetration can be deep. Standard basement construction has become common because excavating to the required depth for footings seems to warrant the construction of a basement, which also offers convenient storage space.

Contrary to perceptions, basements are not required by code, nor is it always necessary to dig deep below the frost line.

Where affordability is important, savings of $10,000 or more on a single house may be achievable by using a properly built frost-protected slab-on-grade. A well-constructed slab-on-grade can provide an alternative to basements where a basement is neither desirable nor needed.

Slab-on-grade construction is used successfully in the commercial sector. Strip malls, warehouses, etc. are built on slabs without a full basement. There is no reason why they should not be used for residential construction, especially where affordability is an issue. However, slab-on-grade construction does not mean eliminating all foundation support for the structure. The design still has to be adequate for the structural loads. It offers an alternate way to build the supporting foundation.

Wherever there is problem soil, high water table or rocky ground, a slab-on-grade is the preferred option. In high water table areas or locations with a high flooding potential, a deep basement foundation is not appropriate, and a slab foundation is a possible alternative.

Slabs on grade can be built two ways: a thickened edge or "floating slab" (fig.1), and a foundation wall with a floor slab poured separately (fig. 2). The floating slab-on-grade has a thickened slab at the edges where most of the load is carried. The thickened portion is cast integrally with the rest of the slab. The thickened edge slab approach would be used in areas with poor bearing capacity to ensure the entire structural load is distributed.

One problem with a floating slab is that large quantities of concrete are used at the thickened edges. In BC, where slab-on-grade construction is common, most slabs are poured with a conventional foundation wall and slab.

A slab-on-grade can also be constructed with grade beams supported on piers, piles or pedestal types of footings.

In the US, the NAHB has published a brochure titled Frost-Protected Shallow Foundation. This publication is available for downloading from the NAHB web site at *www.nahb.com.*

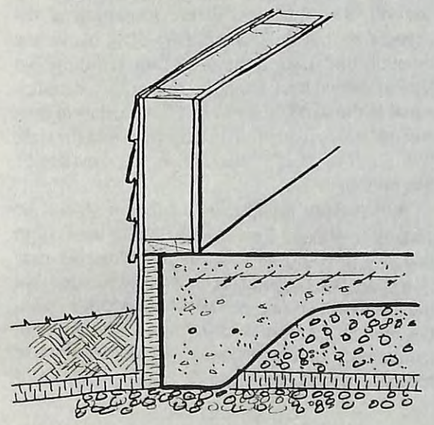


***Figure 1**: Thickened edge floating slab-on-grade*

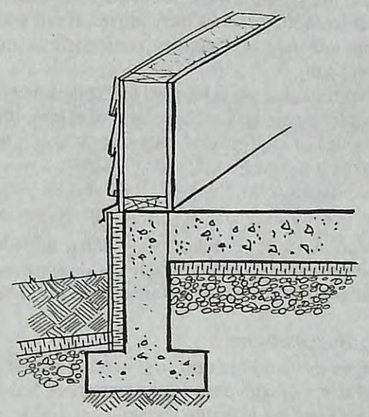
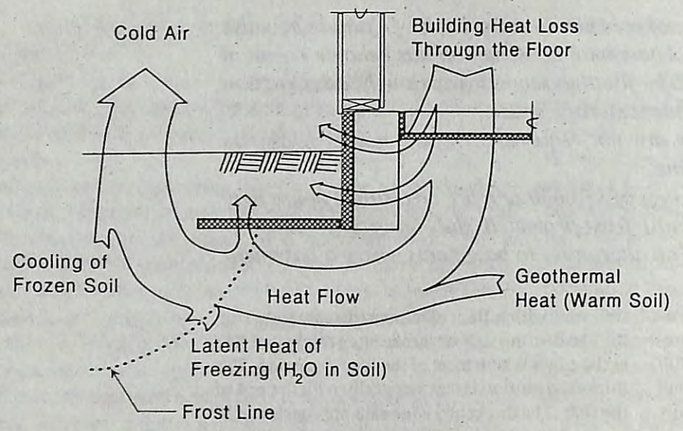


***Figure 2**: slab-on-grade with foundation wall*



To prepare the subgrade, the topsoil must be completely removed. The subgrade material must then be evaluated to determine if additional compaction is required to improve the structural properties of the soil. A soil consultant should be called in if there is any doubt about the bearing capacity of the soil. If compaction is required, the compaction should be the done over the entire area of the building plus a 1,500 to 3,000 mm (5 to 10 ft.) perimeter area. If fill material is added to improve the subgrade, it should be a stable material that can be thoroughly compacted. Buried utility lines, water pipes, sewers, etc. should be covered with at least 50 mm (2 in.) of compacted soil with similar moisture and density conditions as the adjacent soil.

After the subgrade is levelled and compacted to the required density, a subbase layer of at least 100 mm (4 in.) of well-graded rock or gravel can be spread over the entire subgrade to provide a more uniform support for the slab. It should be compacted to a minimum of 98% maximum density at optimum moisture content. The granular subbase should have minimum fines, so it can also provide a capillary break helping to damp-proof the slab.

Slab Insulation

Proper insulation is very important, especially in cold climates with deep frost penetration. Some heat loss from the slab into the soil is desirable to keep the soil warm, reducing the depth of frost penetration. The intent is to reduce slab-edge heat loss and keep the ground under the foundation footings above freezing temperatures.

There are two components of slab heat loss in slab-on-grade construction. First, since the top of the slab must be higher than the exterior grade to prevent any wood members from coming into contact with the soil, heat will be lost to the air through the edge of the slab. Second, heat will be lost through the soil.

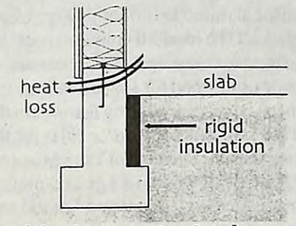
Vertical insulation is used to prevent heat loss through the perimeter of the slab. Insulation must be applied to the outside of the foundation and horizontally outward around the foundation to raise the frost line around the foundation.

Underslab insulation is required to prevent heat loss and reduce energy costs. In BC, full slab insulation (R-12 min) is required if the floor slab is heated. It may be beneficial to increase this to a higher level. Whether or not the slab is radiant heated, an insulated slab helps keep the floor warmer for the occupants.

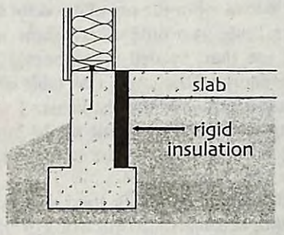
Insulation extending horizontally from the edge of the slab forming an insulating skirt is used to reduce the depth of frost penetration. This insulation should be installed in at least two overlapping layers and should be pegged or spot-glued together to prevent the insulation from shifting during backfill. The thickness of the insulation at the corners should be increased by 50% above the amount used around the rest of the building and should extend back from the corner by a distance equal to the width of the skirt. The insulation skirt should be sloped to drain water away from the slab, with a soil cover of at least 200 to 300 mm (8 to 12 in.) on top.

A minimum amount of insulation should be enough to prevent frost from reaching the bottom of the footing. As the actual depth of frost penetration is very site-dependent, it is recommended that the services of an engineer be retained to determine the amount of insulation required. Rigid foam insulation manufacturers should also be able to provide information. ☼

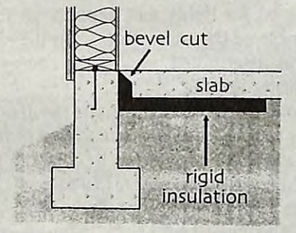
Slab edge insulation is important, but its proper installation is often a challenge. A few possible approaches are presented here. These details apply equally to walkout basements.



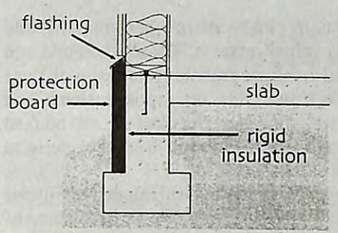
If the slab edge is not insulated, a considerable amount of heat loss occurs across the foundation, even if the exposure is only the minimum 8 inches above grade.



The insulation can be placed vertically along the foundation wall on the inside. This provides protection from insect damage. However, it may complicate installation of finish flooring.

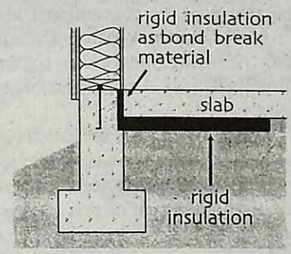


Insulation cut at 45 degree bevel. It is a compromise solution, as it does not offer full insulation protection.



Insulation applied on the exterior is very effective. However, it does require a protection board to avoid mechanical damage and ultra violet deterioration. Detailing of the top of the insulation must consider water management and the connection of siding materials in the wall above. Exterior applied insulation in all instances is the preferred option.

Alternatives to avoid bringing insulation to the top of the slab, and creating problems for finish floor installation, yet not compromising insulation performance.



Rigid insulation used as a bond break between the slab and foundation wall. This requires a notch in the foundation wall, unless the insulation is installed at the time the foundation wall is poured. If the foundation wall is 6 inches thick, and 2x6 framing is used, the top can be reduced to 4 inches thick, to allow a 2x6 sill plate to cover 1½" rigid insulation board.

Illustrations this page from *Setting the Standard*, 4th Quarter, 2000, published by US Department of Energy Office of Building Technology

Energy Use Patterns in Off-Grid Houses

Most of us live and work in urban areas tied into community infrastructures. Those who build and live in rural areas are probably familiar with their own services that rely on septic systems and possibly a well for water. But most are still hooked up to a grid for electricity and, in some regions, to a gas pipeline.

Energy is still the lifeline we cannot live without in an industrialized society. We've become complacent about energy, which is so heavily subsidized that we are not aware of its true costs. And people choose to live in regions beyond the reach of utility grids. Living "off the grid" means being self sufficient for energy needs.

People who live off the grid and have to generate their own energy are presumably more sensitive to energy use which may be a factor in the type of home systems and life style. If these people generate their own power they will tend to be more frugal with its use. Or will they?

CMHC conducted a cross-Canada study to document off-grid energy use and lifestyle patterns to see if there may be lessons or examples of energy conservation that apply to conventional houses. Twelve "off-grid" households across Canada (in Nova Scotia, Manitoba, and British Columbia) were looked at. Each had been occupied for at least two years.

People choose to live off-grid for various political, environmental, financial, and entrepreneurial reasons. In every case, the homeowners interviewed cited more than one of these categories when describing their choice to use a renewable energy source.

Many off-grid homeowners noted that their connection with the weather and the seasons had become more sensitive after going off-grid. They had learned that weather factors were crucial to how their household energy use was being replenished or depleted. For some, this awareness had increased their personal commitment to environmental issues.

The houses studied operated on systems using renewable energy as the primary source of electricity. These systems ranged from simple photovoltaic (PV) installations with diesel generator backup, to complex hybrid systems that use PV, wind and seasonal micro hydro for power. Most of the houses had all the modern conveniences: running water, stereos, computers, fax machines, etc.

Every house used wood for space heating; some had excellent passive solar heating features in their design, and some used wood and/or solar for their water-heating source. Because of the variables in wood heat (the type of wood, its age and moisture content, stove efficiency, quantity of wood used, etc.), the study did not analyze space heating.

It is interesting to note that the homeowners did not make a connection between the energy efficiency of the building envelope - its airtightness and insulation levels - and total energy use. If it were possible to monitor the use of wood for space heating, the findings would likely show much more wood use than needed if the homes were made more energy efficient. (The table shows construction properties of the test houses.)

An air tightness test was done on 10 houses. Two of the houses could not be tested because renovations were being done.

It was difficult to quantify total energy use with precision, because there was a mix of energy sources that could not be metered, and there were no utility meters. However, peak draws could be identified by running each appliance and establishing an estimated length of time it would be used.

The average electrical "baseload" (the amount of energy used for lights and appliances) for a standard house of the same vintage in the same province was determined, as was the energy required for water heating.

Homeowners living off-grid, due to the limits of their energy supply, have easily modified or rearranged their energy use patterns to adjust to that supply. In some cases the degree to which off-grid homeowners have chosen to reduce their consumption would make the home extremely uncomfortable and untenable for most people accustomed to a typical North American "standard of living." However, there are several examples of more or less typical household lighting and appliance mixes that use significantly less power than in an equivalent standard home.

Construction Characteristics of Off-Grid Houses

Location	Year built	Foundation type	Exposed floors	Walls	Ceilings	Windows	Doors	Airtightness, ACH @ 50 Pa	Solar design
Yarmouth NS	1998	concrete basement		R 20	R 40	low-e, argon, insul spacers	metal insulated	2.77	passive solar
BC Gulf Island	1960	crawlspace		R 12	R 12	single pane, sashless sliders, Double glazed patio door	wood & storm	17.28	
BC Gulf Island	1997	walkout basement		R14 & R 20	R 20	clear double, wood frame	wood	n/a	passive solar
BC Gulf Island	1980	crawlspace	R 20	R 12 & R 20	R21 & R28	Single plexiglass, some clear double	wood	n/a	passive solar, solar DHW
BC Gulf Island	1991	crawlspace		R 20	R 20	clear double	wood	15.14	passive solar
Southern Manitoba	1995	pole foundation		R 28	R 32	clear tripple	wood	7.22	passive solar
Southern Manitoba	1980	pole foundation	R 20	R 12 & R 20	R 20	clear double & tripple	wood	5.63	passive solar
Antigonish County, NS	1994	basement & crawl space	R 20	R 20	R 28	clear double	metal insulated	11.24	passive solar
Antigonish County, NS	1997	crawlspace	R 24	R 20	R 20	single, with storms	metal insulated & wood	13.22	passive solar
Belfast, PEI	1997	slab on grade	R 8	R 19	R 42	low-e, argon	metal insulated	2.19	passive solar
Keswick Ridge, NB	1994	crawlspace		R 20	R 40	clear double	metal insulated	5.36	passive solar

Average energy use was about 44% less than in a typical grid-connected house. The big item in terms of energy use was refrigeration. In fact, adequate energy efficient refrigeration was the biggest issue for all houses. Six houses had propane or electric refrigerators. In these, the average reduction of electrical use was closer to 30%. In the six houses that did without refrigerators, the reduction in average energy use was around 70%.

Another challenge for off grid household is the need for a decent AC water pump that doesn't have a large start-up surge.

In terms of water heating, propane or coils/jackets off wood stoves seem to be the norm. One issue is the energy use of the igniter coil in new propane appliances. When the water heater is connected to the electrical circuit, it is difficult to time the big loads with water heating cycles to avoid overloading the inverter.

Lighting is important. Most houses used compact fluorescent lights. Homeowners observed that compact fluorescent lighting costs have not decreased in the last decade, even though the market share of these fixtures has risen exponentially. The same applies to PV panels, where the price point remains similar to that of 10 years ago, even though the market has boomed. ☼

Energy Savings Tips

All off-grid homeowners related similar energy saving themes:

- Lights should be turned off when not in use.
- Task lighting means lower wattage because the light can be closer to the work surface.
- Exterior house lighting turned on all night is a wasteful use of energy; it also obstructs the night sky so you can't see the stars very well.
- Work or study areas set close to south, south-west or south-east windows increase day lighting in those high-use areas, reducing the need for electrical lighting.
- "Light pipes" or "sun tubes" into darker work areas or commonly used rooms increase the overall day lighting.
- When not in use, appliances should be unplugged and not just turned off. There is no need to have a digital clock or timer in every room.
- It is important to buy the most energy efficient appliances you can afford - ideally those without digital clocks or timers.
- The overall energy system can be smaller if high-energy draws can be staggered or scheduled, i.e., don't do the washing while vacuuming. This does not affect grid-connected houses, but does have an impact on life style patterns for those who purchase electricity on a time-of-day basis.
- More efficient sources of energy should be used where possible.

Before you buy, ask yourself: Do I really need another gadget?

Concrete House Awards Program

As part of a marketing effort to promote concrete housing, the cement industry has announced two new awards: an award for energy efficiency will be given to a home that is built and certified to the R-2000 Standard; another award will be given for design excellence.

To be eligible for consideration, the home or multi-family residential project must be primarily constructed of concrete in structural load-bearing applications. The concrete technologies used in the construction must be available commercially. These can include Insulated Concrete Forms (ICFs), pre-cast concrete assemblies, cast-in-place concrete or any other building system that relies on concrete as its primary structural component. The use of concrete for floor assemblies will enhance the value of an entry.

Any single-family home or multi-family project of up to six (6) storeys in height is eligible for the CAC Award for Design Excellence.

Energy efficiency will be assessed based on HOT2000 data produced for the home as calculated by a licensed R-2000 Plans Evaluator. The energy efficiency award will be given to the builder who achieves the lowest calculated energy use as calculated by HOT2000. The reference point will be the R-2000 energy target for the home.

Judging criteria for the design award will include the home's or project's overall appearance, and its curb and interior appeal. The home's functionality and how well it or the project uses concrete building solutions to meet the needs of occupants will also be considered.

The marketability of the overall design and its suitability to the marketplace as indicated by consumer interest and sales performance will also be important factors.

The awards will be made to a builder or developer who is a member in good standing of the Canadian Home Builders' Association (CHBA).

Homes or projects entered for these awards must be completed between January 1, 2002 and December 31, 2002. The deadline for entry is December 30, 2002 ☼

Information
Cement Association of Canada Housing Awards
Suite 1500, 60 Queen St.
Ottawa, Ontario K1P 5Y7
Fax: 613-563-4498 Email: infor@cement.ca

R-2000 Home Reduces Natural Gas Consumption by 70%

The best advertising is always a satisfied customer. Wisa Healthy Homes, a Vancouver R-2000 builder, was happy to receive a note from a recent customer along with a copy of the customer's utility bills. The homeowner explained how satisfied he was with his new R-2000 home, and especially the low utility bills.

The new home was a replacement for an old 850 square-foot, typical Vancouver house built in 1943. It had single pane aluminum windows, a wood burning fireplace, and a gas range but no washer/dryer or dishwasher. Although there was no air test done prior to demolition, it is likely that the house was very drafty, with an air leakage rate in excess of 8 air changes per hour at 50 Pascals.

The owners had lived in the original house for several years. They reported that they set back the thermostat to 18°C between midnight and 7:00 a.m., and from 8:00 a.m. to 6:00 p.m., otherwise the temperature was kept at 21°C.

The new replacement house was built as a certified R-2000 house. It has 2174 square feet, and includes all modern conveniences, including gas range, gas dryer and a direct vent natural gas fireplace (with a standing pilot light). The temperature is kept at 22°C, but the heat is turned down to 20°C between midnight and 7:00 a.m., and from 8:00 a.m. to 6:00 p.m. They also turn off the pilot light in the gas fireplace between April and September.

The family now has a newborn baby. Despite the larger house with more appliances, the warmer indoor temperatures, and a different occupancy pattern, total energy consumption has decreased. Energy use in the original house was 20.9 kWh/m²/year for electricity, and 1.03 GJ/m²/year for natural gas. By contrast, the new house consumes 24.09 kWh/m²/year for electricity and 0.31 GJ/m²/year for natural gas.

The 15% increase in electricity use could be accounted for by the larger number of lights and appliances in the house, the regular use of a dryer, and the fan in the continuous ventilation system. The house uses a Lennox Completeheat combination heating/domestic hot water system, which unfortunately does not have the most efficient blower motors. Because the unit is running continuously as part of the ventilation distribution system, the blower motor consumes more electricity than is needed. Had a more efficient motor been available, the energy savings would have been more significant.

However, gas consumption for space heating and hot water heating decreased by 70% in spite of warmer temperatures being kept in the house and a greater use of hot water. ☼

Higher Energy Prices Forecast

So you think last winters' high energy prices are just a bad memory? That we don't need to worry about energy use or efficiency now that prices have dropped?

Cheap oil and gasoline may be in the cards in the near term, but a petroleum association conference in Colorado in early March was told that we can look forward to a price increase for natural gas and electricity.

As the US economy recovers and begins to grow again, more natural gas will be needed to generate electricity. US natural gas production from existing fields will decline 29 percent this year, mainly because older wells in the Gulf of Mexico are being depleted. Record levels of spending for natural gas drilling during much of the past two decades has failed to reverse the production decline. Since North America is now an integrated energy market, what happens in the USA will affect Canada.

Even if you discount the need for energy efficiency improvements because you have doubts about the climate change issue, the payback for upgrades will only get better with time because of changing energy prices. ☼

R-2000

For information on the R-2000 Program, contact your local program office, or call
1-800-387-2000
r.2000@nrcan.gc.ca
http://ee.nrcan.gc.ca

Can Building Codes Guarantee Building Performance?

Proponents of improved standards, be they energy efficiency or other technical issues, often promote tightening existing codes and standards. The reasoning is that, at the very least, the higher standards will level the playing field at a higher performance standard. However, the results are not always achieved unless there is adequate scrutiny of compliance.

In 1998 a new residential energy conservation code went into effect in Massachusetts. The new code gave builders and architects greater design flexibility. A study to evaluate the effect of the revised code showed that, although there was a potential for yielding greater energy savings, the intended benefits were not achieved because only 46% of the houses complied with code requirements.

In order for all requirements to be met, builders have to build houses that meet the code and building officials have to do the necessary inspections and enforce it, which was not being done.

The Massachusetts state agency responsible had done a good job of informing residential construction professionals about the features of the code regarding the design, permit application, and construction requirements for new residences. However, everyone indicated that more information on energy efficiency was needed, especially on new products and techniques.

MAScheck code-compliance software was most commonly used to demonstrate compliance at the permit stage. Although some builders were interested in prescriptive approaches, which are also available, only 2% of the houses used the prescriptive compliance approach.

All local officials used *MAScheck* reports to verify compliance. Most builders and designers were supportive of the software and its flexibility, but few made use of that flexibility.

More telling, few building officials checked building specifications on the *MAScheck* printout against the building plans, or performed any site checking between the *MAScheck* specifications and what was actually built.

On-site surveys confirmed that large discrepancies often existed between the data in the filed *MAScheck* output and the characteristics of the building as built. Floor areas and perimeters varied significantly in nearly 80% of the cases, and insulation levels differed substantially in about one-third of the cases. However, energy-code enforcement varied significantly among communities, although the variation was not substantially different than it was from other parts of the code.

Builders and code officials suggested that there might be a need for a more checklist-oriented approach for reviewing energy efficiency requirements, at least in organizing the inspection process. ☼

Rooftop Gardens

Sod roofs are common in some parts of the world. In Canada they tend to be seen as a quaint oddity for a fringe crowd. However, rooftop gardens have the potential to reduce both urban heat island effects, storm water runoff. They can also have other benefits such as adding urban green spaces and increasing property values.

Although the concept of green roofs is more likely to be used in commercial or multi-family projects, even single family homes can be built with sod roofs, through perhaps at a premium cost.

A major barrier to the widespread adoption of rooftop gardens in Canada is a lack of technical information on the benefits and durability of these gardens in a Canadian context. The IRC and its partners launched a two-year research project in 2000 that will combine field study and computer simulation.

At its Ottawa campus, the IRC has constructed a rooftop wild flower garden over a modified bituminous roof system. The temperature, relative humidity, heat flows, solar reflection, soil moisture content and storm water run-off data are being gathered to provide field data to validate a computer model. Climate data from all regions of Canada will eventually be incorporated into the model to predict the success and benefits of rooftop gardens across the country. ☼

Letters to the Editor

Re: Editorial, Solplan Review No. 102, January 2002

I have been an avid reader of Solplan Review for some time. It has always been timely with its articles.

I wanted to make a comment on your January editorial. There is a lot of truth in what you say and God knows we haven't done near enough, but although we humans are innately selfish, which is really the bottom line as to where we have ended up, you must give credit where it is due.

I can remember when there was no unleaded gas, no catalytic converters, no radial tires, no R2000 houses, no efficient and affordable HVAC's, no HRV's, no efficient fuel burners, no smog laws, no waste effluent laws, no outside burning laws, no recycling, no ban on DDT, no select logging, and so on.

I remember in my youth, many years ago in Southern Ontario, watching raw sewage float down the Detroit River, smog over the twin city skyline, not being able to eat the fish we caught because of mercury, many lakes being almost lifeless from acid rain. Some of the great lakes like Erie and Ontario turning green.

I was there last year after more than 25 years and found an astounding difference to all those things above. It was heartening. However, the large houses on large lots syndrome is still the norm. I can remember many years ago, when I was building there, trying to get small lots approved for affordable houses. It was a waste of time. It appears as if that hasn't changed.

And that rogue character . . . he's like a single cancer cell . . .

Please keep up the good work. I look forward to Solplan Review.

Barton Blainey
Victoria, BC

Re: Performance of Displacement Ventilation System and You Asked Us: Drying Closets, Solplan Review, January 2002

Our firm provided the mechanical engineering design and commissioning of the CMHC house for the Hypersensitive. I was not aware that the house had been monitored and thanks to your publication, I am much the wiser.

I would like to highlight the aspect that equivalent outdoor air distribution was achieved without a forced air fan (e.g., typical electrical demand of 500 W). Instead, heating is distributed with a 150-W pump via the radiant system. The house also had a custom heat recovery ventilator with high-performance, low pressure-drop filtration (HEPA and carbon) and high efficiency ECM fan motors.

For summer comfort, there was a low intensity compressor based air-conditioning system that delivered chilled ventilation air and rejected the condenser by superheating the exhaust. By preheating the mass of the house with a set point of 22°C and allowing it to rise slowly to 26°C on a peak day, an air-conditioning system of less than half the conventional capacity can be used to maintain comfort.

This house also had a drying closet which was heated by adding a valved hydronic loop to the radiant system. The closet was vented by diverting the house exhaust to the bottom of the closet. Horizontal serpentine copper piping created a shelf for drying towels, socks and boots. Clothes were accommodated above on hangers supported by a standard rod. A better solution for the shelf would be a horizontal Runtal rad.

It would have been appropriate to give credit to those involved in the project such as Peter Russell, CMHC project manager, formerly with the Research Division, mechanical project manager Doug Geddes, and Greg Allen and myself for low energy consulting and mechanical engineering.

Mario Kani, P. Eng
Allen Kani Associates, Toronto.

Thanks for the clarification. The National Research Council of Canada report, which we used for the item described the monitored results, did not provide any information or acknowledgements about project participants. Ed.

Technical Research Committee News

Canadian Home Builders' Association

Proposed Changes to the National Building Code

A review of the National Building Code is now underway. All proposed changes will first be reviewed by the provinces and territories before a public consultation on technical changes to both the national and provincial codes is held in October 2002.

Although the intent is to issue the National Building Code as an objective-based document, with simple performance statements, a second part will look very much like the current document and offer accepted solutions to of the problems raised by the objective-based code.

A large number of changes are being proposed to the second part. Here are highlights of some of the more significant changes currently under discussion, and which will likely be incorporated into the public consultation documents:

Stairs, Handrails, and Guards

A number of changes are proposed. In residences, some are a relaxation of current requirements, including allowing two sets of winders in a flight, 45° winders, and combined straight and curved stairs in a flight. Some increase stringency, such as increasing the minimum run from 210 mm (8¼ in.) to 230 mm (9 in.), and increasing the minimum headroom.

Ventilation

This topic remains a challenge. The issue is how to draft a simple, enforceable minimum prescriptive standard for code users. A task force has been working on this for some time. Recommended changes include:

If spillage-susceptible combustion equipment is present, all exhaust devices other than the principal ventilation fan (e.g., bathroom and kitchen exhaust fans) must be linked to make-up air fans of the same capacity.

If no spillage-susceptible combustion equipment is present, an exhaust-only ventilation system can be used, but some means of circulating incoming air will be required.

If the mechanical ventilation system can depressurize the dwelling, and the dwelling contains combustion equipment or an attached garage, the dwelling will have to include carbon monoxide detectors.

Carbon Monoxide Detectors

CO detectors would be required in any dwelling that incorporates any form of combustion equipment or an attached garage, regardless of the configuration of the ventilation system. A similar change is proposed to Part 6 of the NBC and thus would apply to all residential buildings, regardless of size.

Lateral Load Resistance

Lateral load resistance is often overlooked in the design of Part 9 buildings because many Part 9 buildings, especially houses, have a lot of inherent lateral load resistance. However, larger houses with non-traditional configurations (e.g., open floor plan, two-storey high rooms) are becoming more common. This raises the question of whether or not shear load resistance can continue to be overlooked. Changes proposed for Part 9 would define the configurations (combinations of braced walls and openings) where lateral load analysis will be required.

In a few areas with high seismic loads (mainly in south coastal British Columbia), or very high wind loads (e.g., Pincher Creek AB, Harrington Harbour PQ, Cape Race NF) lateral load analysis would be required regardless of building configuration.

Keeping Out Rain

Concerns about the performance of building envelopes and requests from many builders for rain screens has led to the development of an extensive set of proposed requirements relating to the resistance of walls to moisture entry.

In some situations there will be a code requirement that a wall incorporate a rain screen. Normal vinyl or metal siding placed over sheathing paper would satisfy both of these requirements by virtue of the vented spaces behind the siding.

Locations where the rain screen requirements would apply will be identified by a new climatic indicator - a moisture index - that will be added to the climatic data in Appendix C. The index will be a single number that reflects both the amount of rainfall a location receives and the duration of drying periods.

Coastal areas tend to have high moisture indices and prairie areas tend to have low moisture indices.

The Technical Research Committee (TRC) is the industry's forum for the exchange of information on research and development in the housing sector.
Canadian Home Builders' Association, Suite 500, 150 Laurier Ave. West, Ottawa, Ont. K1P 5J4
Tel: (613) 230-3060
Fax: (613) 232-8214
e-mail: chba@chba.ca

Other Proposed Changes

Specific provisions for insulated concrete forms (ICF) are being proposed.

Windows large enough to be used for emergency egress in basements will be required even if there is no bedroom in the basement.

Ontario Fall Protection Training Reminder!

The death of another construction worker in September 2001, after a fatal fall on a residential construction site, drives home the need for mandatory fall protection training. In the year 2000 almost half of the construction fatalities were due to falls.

To combat this ever-present hazard in the industry a new Ontario law effective June 12, 2002 will require every construction worker who may use a fall protection system to be adequately trained in its use. Employers must ensure that their workers have been trained in the specific fall protection equipment and applications they will encounter on the job. ☼

The Value of Trees

Urban Trees Can Save Hundreds of Millions

Economists and environmental doubters should take note of a recent Oregon study. It shows how the tree canopy of the Willamette/Lower Columbia Region (this area includes Portland, Oregon - and a population of more than two million) provides hundreds of millions of dollars in environmental and economic benefits such as reducing stormwater runoff, energy usage, and air pollution.

The region's trees remove 178 million pounds of pollutants annually, a savings valued at $419 million. Sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone and particulate matter are among the pollutants trees absorb.

The study noted that the area's tree cover declined by 22% over the past 28 years, costing communities billions of dollars in lost benefits. Losing tree cover reduces environmental quality and the overall health of a community. If the 1972 tree canopy had been retained, an estimated 58 million tons of carbon would not have entered the atmosphere. The lost tree cover increased stormwater runoff that costs an estimated $2.4 billion to manage and would have removed 138 million pounds of pollutants annually, valued at $322 million per year.

The existing tree cover is saving communities in the region an estimated $20.2 billion in stormwater management costs (the amount it could cost to build a facility to handle that amount of stormwater runoff). Besides reducing the need for stormwater facilities, trees act as filters that help purify water. Water quality is of special importance in the US Pacific Northwest because of the need to improve aquatic habitats for threatened and endangered salmon species.

Trees also help shade and cool homes during hot summer months, thus reducing the amount of electricity needed to run air conditioners. Trees provide an estimated $1.86 million in annual energy savings for communities in the area. Reducing energy use also reduces the amount of carbon emissions by utility companies. Direct tree shading prevents approximately 140,000 tons of carbon from being emitted into the atmosphere annually.

Standard urban development approaches create a grey infrastructure (sidewalks, roads, and buildings) by removing green the infrastructure (trees). This tree-loss trend has adverse environmental and financial effects and degrades the overall health and quality of urban, suburban, and rural environments. American Forests recommends that urban regions maintain an average 40% tree cover. ☼

Regional Ecosystem Analysis for the Willamette/Lower Columbia Region of Northwestern Oregon and Southwestern Washington State: Calculating the Value of Nature.

The study was conducted by American Forests, a non profit conservation group founded in 1875 which promotes the awareness of the interdependence of communities and forests. Their program focus is on activities promoting the restoration and maintenance of healthy ecosystems and communities. This study was supported by the USDA Forest Service, Washington State Department of Natural Resources, the Oregon Department of Forestry, and officials from the cities in the study area. More information: www.americanforests.org

NRC·CNRC

Specifying Acoustical Criteria for Buildings

By A.C.C. Warnock

If rooms are to function properly from an acoustics point of view, then criteria for acoustical performance in the completed building must be set. Moreover, the criteria must apply to complete rooms, not just to the structural elements. By focusing on the performance expected from the system as a whole, key issues may be identified and problems avoided at the outset.

Three basic acoustical properties of rooms determine in large measure whether a room will function properly:

- the attenuation of sound propagating between the room and adjoining spaces;
- the background noise level in the room due to air-handling, plumbing, and mechanical systems; and
- the reverberation of sounds within the room.

Sound attenuation

Intrusive sound in multi-family homes (music, TV, voices, footsteps) needs to be attenuated by the building structure. Building components (walls, floors etc.) are ranked according to their ability to stop airborne noise using the sound transmission class (STC)[1]: the higher the STC rating, the greater the sound attenuation. Sound transmission class for components is measured in a laboratory[2].

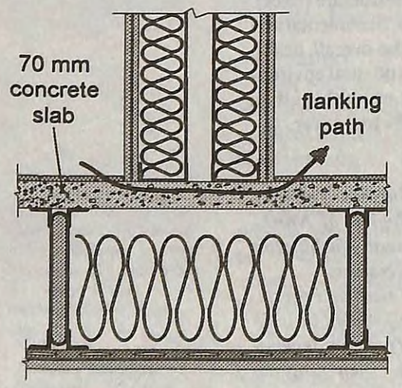


***Figure 1**: Flanking transmission along a floor. (The wall has double steel studs, two layers of gypsum board each side and sound-absorbing material in the cavity. The floor has ceramic tiles on a concrete deck on steel joists and resilient channels to support the ceiling.)*

Building codes commonly specify the minimum STC for building components only, not the sound isolation for complete room pairs. While selecting components is an essential part of design, ultimately the goal is to have a "system" that provides the required composite attenuation between rooms. The walls, floors and other elements that make up a building all allow sound to propagate between adjacent rooms, often causing the actual sound attenuation to be less than expected.

To ensure that a desired sound attenuation between rooms is achieved, designers should specify the apparent sound transmission class (ASTC). The ASTC represents the attenuation due to the combination of all sound paths between the rooms in the finished construction, not just the attenuation due to the primary partition. To determine the ASTC, measurements are made according to ASTM E336, but no steps of any kind are taken to reduce flanking sound transmission or to correct construction errors; the rooms are tested exactly as found.

Figure 1 illustrates the shortcomings of focusing on elements rather than the system. A designer may choose to have an apparent STC of 55 for a project. To meet this requirement he selects the wall and floor shown in the figure. Each will attain an STC of more than 60 when tested separately in a laboratory. As assembled, however, flanking sound transmission along the floor slab will bypass the wall, resulting in a measured ASTC between the upper rooms of only about 48. The wall does not provide the attenuation it is capable of because it is not the only path for the sound. Footsteps and other impact sounds will also propagate easily along the floor slab; the rest of the structure has little influence. There is no standard test method for evaluating such impact transmission between two side-by-side apartments. If there were, the side-by-side impact insulation class (IIC) in this case would be less than 25 and would be determined primarily by the concrete slab. Thinking about the performance required from the system could identify this problem and allow it to be rectified. The lesson to be learned is that specifying STC for components does not guarantee an effective sound isolation in the complete system.

Meeting a specification for the ASTC requires informed selection of components, carefully designed connections between walls and floors, attention to detail during construction, and preferably testing of the completed assembly to confirm that the specifications have been met.

Impact sound insulation

The standard tests for impact sound insulation[3] in laboratories generate a single-number rating called the impact insulation class (IIC) or the field impact insulation class (FIIC)[4]. The E1007 field test procedure automatically takes into account the effect of any flanking transmission or construction errors in the measurement.

For a given floor type, IIC depends strongly on the floor covering used. For example, a 150-mm concrete slab finished with ceramic tiles will have an IIC of about 30; the same slab finished with a carpet and underlay will have an IIC of more than 80. The harder the surface of the floor, the lower the IIC.

There are no impact sound criteria suggested in the National Building Code but it would be foolish to ignore impact sound insulation when designing homes that are intended to have good acoustical properties.

Sound attenuation criteria

Ideally, sound attenuation criteria for buildings would be set using average values of music, TV and speech levels, footstep and other impact noise levels, average background noise levels and estimates of the tolerance of occupants in each situation. Table 1 suggests ASTC and FIIC criteria for various occupancies.

In some cases, higher acoustical ratings may be necessary. An increment of 5 dB is commonly used between one level of sound insulation or noise and the next; changes of 5 dB correspond to easily noticeable change in sound insulation or sound pressure level.

Table 1. Suggested acoustical criteria for some occupancies

	Recommended Minimum Sound Attenuation		Recommended Range for Background Noise, dB(A)
	ASTC	FIIC	
Multi-family homes	55	50	35-40
Bedrooms in residences	55	50	30-35
Private offices	45		40-45
Meeting rooms	50		35-40

Note: Reverberation time is important for meeting rooms and should be about 0.5 seconds. In other rooms mentioned in the table, this factor is not important.

Background noise levels

The background noise criterion selected for each space depends on the normal activity. Back ground noise levels recommended for bedrooms are based on studies of how noise interferes with sleep. For living rooms where people try to relax or in offices where a calm environment is needed to support concentrated mental effort, noise levels are still important but can be less stringent than those for sleeping accommodation. ☼

Notes:

1. ASTM E413
2. ASTM E90
3. ASTM E492 and ASTM E1007
4. ASTM E989

Dr. Alf Warnock is a senior research officer in the Indoor Environment Program of the National Research Council's Institute for Research in Construction.
Alf.warnock@nrc.ca
Other information on sound transmission can be found in IRC's publication series, Construction Technology Updates.

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Energy Answers

Rob Dumont

What is Optimal Value Engineering, and how can it lower the cost of heating a building?

Optimal Value Engineering (OVE) is a cost control technique widely used in some manufacturing industries. The basic idea in OVE is to "engineer" each component used, rather than simply follow techniques used in the past. OVE systematically compares and selects alternative materials and methods to determine the least costly combination that will result in an acceptable product.

Here's a quote from a 1984 article about OVE applied to housing "The real point made by OVE is that the way your grandfather built is not necessarily the way to go today. The houses were very energy inefficient and often either underbuilt or overbuilt. They weren't engineered; they were just "the way we do things," with results both good and bad. The aim of the optimal value engineering project (of the National Association of Home Builders of the United States) was to look rationally at building techniques and costs and consistently choose the least expensive option that is still acceptable."

In Canada, OVE framing techniques are more commonly called Advanced Framing.

What are some common Advanced Framing (OVE) techniques?

Advanced Framing techniques include design concepts, construction, framing, and detailing methods, final architectural finishing and detailing, and new approaches to plumbing, heating and electrical systems.

Many building practises in housing are tradition-based. For instance, wall studs are often placed at 400 mm (16 inches) on centre on one story frame houses even though wider spacing would be allowable from a structural and code standpoint. Double top plates and three-stud corners are also common. A 1988 study conducted in Alberta by Richard Vanderwell concerning residential housing suggested that a 10% savings could be achieved in the cost of a new dwelling by applying the full range of value engineering techniques.

In addition to cost savings, the value engineering measures are also "green" because they reduce the quantity of materials in the building without compromising the intended use of the building.

Some representative Advanced Framing techniques include the following:

1. Use exterior grade panel products as the exterior finish; removes the need for sheathing. This of course assumes that appropriate moisture management details can be accommodated.

2. Build all framing on a 600-mm (24 inch) basis except where structural requirements may require narrower spacing. This reduces the number of wall studs by about compared with studs on 16 inch centres, and allows more insulation to be placed in the walls, reducing heat loss and the size of the heating system.

3. Place floor joists at 600 mm (24 inch) on centre. This reduces the number of joists by about compared with 400 mm (16 inch) spacing. Floor sheathing thickness and joist stiffness will have to be upgraded to yield equivalent performance.

4. Space all studs, joists and rafters at 600 mm (24 inch) on centre consistently throughout the house structure. With this approach single top plates may be used on the walls. The accompanying figure shows a floor/wall/truss system with 24 inch spacing. With this approach standard drywall sheets will have to be cut to fit on the walls if standard height studs (92 inches tall) are used.

5. Cantilever the floor areas over foundations and main floors in one-storey and two-storey construction to allow design variations and increased floor area without complicating the foundations.

6. Where non-loadbearing partitions run parallel with the floor joists, it is not necessary to provide double floor joists under all walls; 38 x 89 mm (2 x 4 in) blocking spaced at 1.2 m (4 ft) is sufficient.

7. Use metal drywall clips at corners, partition wall intersections and ceilings to save wood materials and allow placement of more insulation.

8. Use 38 x 64 mm (2 x 3 in) wood studs placed at 600 mm (24 in) on centre in non-loadbearing interior partitions.

9. Co-ordinate the location of door and window openings in the exterior wall with the modular stud spacing to eliminate or reduce the use of cripples and jack studs, regardless of whether the walls are loadbearing.

10. Where windows are located in non-loadbearing exterior walls, eliminate the use of headers, jack studs and cripples.

11. Single stud framing can be used for non-loadbearing partitions for passage doors, closets, and other openings; there is no need for cripples.

12. Framing and finishing at closets can be simplified by using ceiling-height closet doors.

13. Eliminate or use less expensive lumber for rake and eave trims to eliminate soffit boxing-in.

14. Arrange all of the typical plumbing groupings such as baths, kitchen and laundry back to back on a common wall to minimize piping runs and venting duplication.

15. Downsize the heating plant to match the peak heating requirements of the structure with some additional capacity for backup; many heating systems are grossly oversized for current modern buildings.

How will these techniques reduce the heating bills?

In a typical house with standard framing at 16 inches on centre, the plates, studs, headers, jack studs and cripple studs amount to about 23% of the exterior wall area. Using advanced framing techniques, with studs at 24 inches on centre, and with unnecessary jack, cripple, and redundant studs removed, the wood parts of the wall are reduced to about 15% of the exterior wall area.

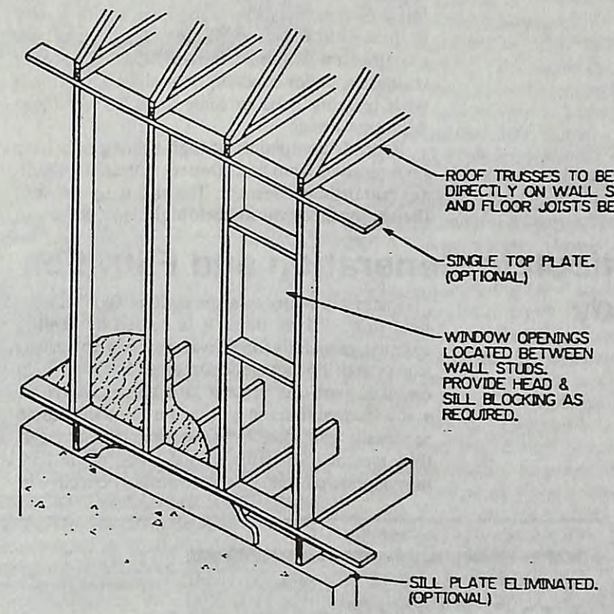
The overall R value of a wall framed with advanced framing (ignoring windows and doors) will be about R16 assuming glass fibre insulation is used; while the overall R value of a wall framed with standard framing practices is considerably less at about R14.5, because when compared to glass fibre insulation, wood is a poor insulator, with an R value of only about R 1.25 per inch.

Thus, in addition to the lower material cost for the advanced framing because of reduced lumber usage, advanced framing can incorporate more insulation and have a higher R value.

What about building quality–won't it be lower with advanced framing?

I would argue that quality can actually be improved. Allowing more insulation in the envelope of the building implies a higher quality building. Removing redundant framing members does not cheapen a building; it just reduces overbuilding and waste of resources.

IN-LINE FRAMING USING MODULAR SPACING OF MEMBERS


ROOF TRUSSES TO BEAR DIRECTLY ON WALL STUDS AND FLOOR JOISTS BELOW.
SINGLE TOP PLATE. (OPTIONAL)
WINDOW OPENINGS LOCATED BETWEEN WALL STUDS. PROVIDE HEAD & SILL BLOCKING AS REQUIRED.
SILL PLATE ELIMINATED. (OPTIONAL)

Where can I get a good reference on advanced framing?

In 1998 the Greater Vancouver Regional District and the Canadian Home Builders' Association of BC produced the excellent book ***Advanced Framing Techniques: Reducing Costs Through Resource Efficient Building***. To order a free copy call the GVRD at 604-436-6818 or *thomas.mueller@gvrd.bc.ca.*

References:

*National Association of Home Builders Research Foundation, Inc. "**Reducing Home Building Costs with OVE Design and Construction, Guideline 5**", U.S. Department of Housing and Urban Development publication, November, 1977*

*National Association of Home Builders Research Foundation, Inc. "**Manual of Lumber and Plywood Saving Techniques for Residential Light-frame Construction**" U.S. Dept. of Housing and Urban Development publication, June 1971*

Bubble Pack Foil Coated Insulation

There seems to be a continuing fascination with reflective insulation products, especially when aggressive marketers get involved. Bubble wrap/ foil coated materials have their use, but they must be used within strict conditions. They can be used as part of a wall system, but are NOT to be used as insulation under concrete floor slabs. Yet this is what is being done in some areas, especially in Atlantic Canada.

Recently complaints of high heating bills have been received from homeowners with in-floor radiant heat in their basement. The high temperature of the heating fluid contributes to high heat loss through what is essentially an uninsulated slab.

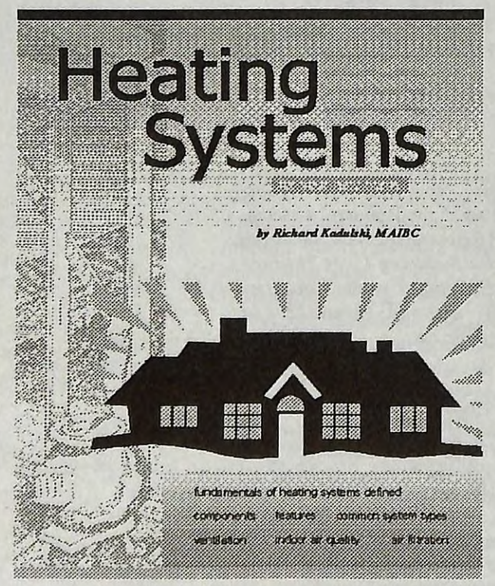
The bubble pack sheet material typically consists of a polyethylene double bubble pack, 8 mm thick, in 4 foot wide rolls made up of two layers of 4 mm thick air bubbles separated by a thin sheet of polyethylene. The two surfaces of the double bubble pack are finished with a thin aluminum foil.

The only construction assembly system in which bubble pack will provide insulating properties is one which contains an airspace. When used in a wall, the stud cavities are filled with fibre glass batt insulation and on the interior a double set of horizontal furring strips is used to define an airspace on either side of the reflective insulation. The construction is defined in CCMC report No. 12342-R.

Particulate Generation and Filtration Study

There are many misconceptions about household dust. Many think it is caused by heating systems, especially forced warm air systems. Heating system do not generate dust, but may help circulate particles present in a house. A recent study showed that the particulate cloud in a home is actually generated by the occupant. Because of this, typical inline filtration devices, while they may capture particles, they are not very effective in improving the indoor particulate environment.

Another, companion study has found that air, during and after vacuuming, is much cleaner over hard surface floors than over carpeted floors. There is an increase of between 10 times and 100 times the suspended respirable particles over carpeted floors before, during and after vacuuming, compared with hard surface floors. The mechanics of this are not understood, but is important, in the management of particulate loading in houses.



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Climate Change Indicators

The US Environmental Protection Agency reported in February that US greenhouse gas emissions have increased 2½% in 2000, to a level 14% above 1990 emissions. The EPA attributes the increase to robust economic growth, cooler winter conditions, and a decreased output from hydroelectric dams.

The US National Oceanic and Atmospheric Administration announced that average global temperatures in January 2002 made it the warmest month on record. Even warmer global temperatures are expected this summer, as a continuing warming trend in the tropical Pacific waters signalled the likely development of El NiÁo conditions within the next three months, according to researchers. Meanwhile, new research from Australia's Commonwealth Scientific and Industrial Research Organisation suggests that El Nino events may be getting stronger due to global warming.

These events may seem beyond our control. To reduce their effect will require energy and resource efficient practices on all our parts. This means more energy efficient homes, and use of more fuel efficient vehicles and equipment.

SOLPLAN REVIEW is an independent Canadian Journal published 6 times per year to serve the needs of professionals and interested lay persons. It provides news, technical details, new product information, insights and commentary on developments covering all aspects of building science and energy efficient building practice for new and retrofit residential construction. Technical information is presented in a clear, concise manner, without resorting to jargon.

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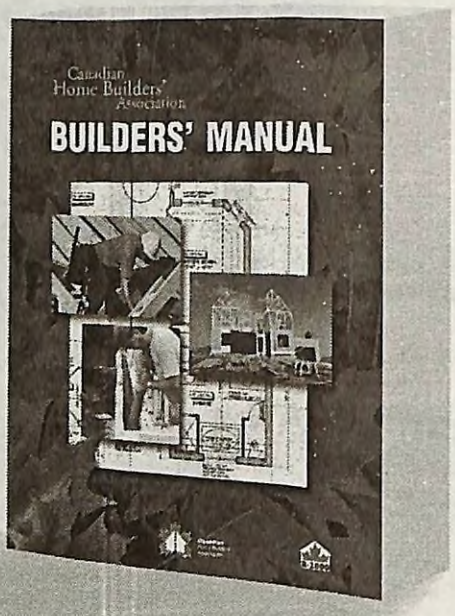

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